United Nations
Economic Commission for Africa

Blockchain Technology in Africa

DRAFT REPORT

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1. Introduction

The SDGs and Agenda 2063 set out a vision of global and continental development that recognizes the critical role of technologies and innovation in tackling most of the challenges of sustainable development. ICT plays and continues to play a role in addressing these challenges. The Internet continues to spawn new technologies that change the way people interact with their environment in significant ways, in areas as diverse as social relations, the way business is done, and economies. One such agent of change is "blockchain", a revolutionary technology[1] that allows parties to transact directly with each other without the need for intermediaries as central trusted third parties. *The Economist*[2] calls the blockchain technology "the trust machine", because "it lets people who have no particular confidence in each other collaborate without having to go through a neutral central authority."

Blockchain technology underpins "bitcoin", the decentralized cryptocurrency. It is, however, much more than that: it can be thought of as a "chaincode" of information written in a single distributed register (or ledger) by participants. It can be inspected by participants, however, no one participant controls it. This register contains pages (or blocks) that are modified every ten minutes with new information.

Its origins underpin the technology for the cryptocurrency bitcoin, but blockchain technology does not stop there. It the opportunities of multiple use that this technology offers continue to expand. Its advantages include decentralization, security and transparency, high resistance to outages, auditable and efficient. Its use goes much further and extends to many sectors that range from financial, governance, education, health, industrial (including chemical processes and mineral processing), energy, environment, and IT. According to the firm Research and Markets[3] from the United States of America, the worldwide cryptocurrency and blockchain technology market will grow by 35.2 per cent during the forecast period 2016–, to touch an aggregate of $42.16 billion by 2022. Most of this growth, however, will take place in the United States, followed by Europe, the Asia-Pacific and India.

In Africa, despite the development of the mobile cellular with more than 1 billion SIM cards and 140 mobile money services in 39 countries, or over half of the 277 total services globally, as of December 2016[4], there are very few concrete cases of the use of or adoption of blockchain technology. Solutions are developed within the constraints of a poor understanding and knowledge of the technology, especially in sectors other than banking. In addition, central banks do not have regulation in place for innovation technologies of this kind. However, Bitcoin, nevertheless, is gaining ground in countries such as Ghana, Kenya, South Africa, Tunisia and Uganda, where it is

[1] http://www.hlmediacomms.com/2016/09/19/blockchain-in-africa/
[2] *The Economist* , 31 October 31- 6 November 2015.
[3] https://www.researchandmarkets.com/research/34frjf/worldwide
[4] GSMA's *State of Mobile Money in Sub-Saharan Africa* report-2016

used generally for money transfers. Banks in South Africa, including the Reserve Bank, are beginning to accept the innovation of digital currencies and blockchain technology despite the differing opinions of regulators on matters such as cryptocurrencies. Studies reveal that blockchain technology can provide opportunities to disrupt businesses in the financial sector and offer new growth for startups across the continent. Tunisia is the first country in the world to issue its national currency via an application that operates through blockchain. Uganda has started regulating bitcoin, and Senegal plans to introduce a digital currency (the "e-CFA") based on blockchain technology.

With the range of applications being implemented in the continent, from enabling micropayment systems to digital identity management to smart contracts, there is no doubt that blockchain-based solutions can leapfrog traditional or non-existent technology infrastructures in African countries. Such revolutionary developments are the drivers of a new era of more inclusive growth in which "no one is left behind". To boost growth, Africa could take advantage of the blockchain technology in multiple sectors, including: international transfer of funds, land and property registers, fight against counterfeit medicines, agriculture and mining (in particular, the traceability of various raw materials), certification of diplomas and other administrative documents, and organization of elections. Blockchain technology represents the potential to enhance transparency and reduce long-standing inefficiencies and costs within multiple sectors of any economy and is therefore of particular relevance to African economies. If Africa is to use blockchain technology as an inclusive factor of development, however, there are many challenges remaining, such as policy and regulatory implications, access to ICT infrastructures, security and trust aspects, and energy consumption.

In this context, this study aims to explore the potential of blockchain technology in Africa as it is considered one of the revolutionary and most intriguing technologies currently in the market. Entrepreneurs, startup companies, investors, global organisations and governments have all identified blockchain as a revolutionary technology. The study therefore aims to demystify blockchain technology and provide policy recommendations as to how countries could embrace the technology towards achieving their economic transformation agenda.

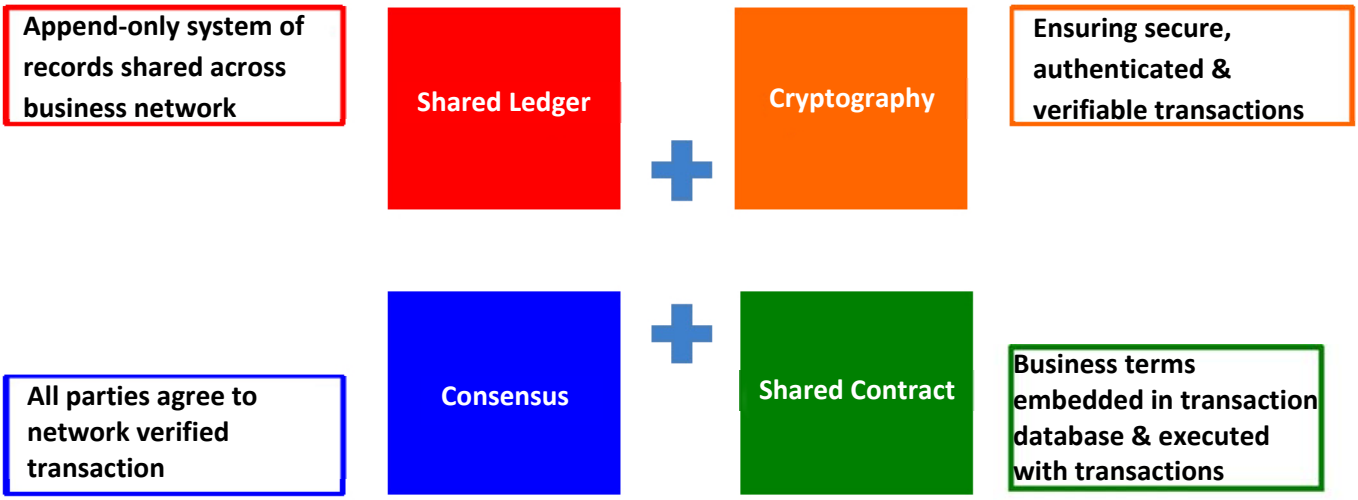
2. Introduction to blockchain technologies:

2.1: Concept and Definitions:

The blockchain (chain of blocks) is the emerging technology that has gained popularity within few years. Blockchain technology offers distinct advantages over database technology as it provides for trustless recording of transaction data without relying on an existing intermediary like a bank in the case of financial transactions. It offers its participants a highly secured ledger system

across the distributed network[5] . Blockchains are shared ('distributed' or 'decentralised') digital ledgers which use cryptographic algorithms to verify the creation and transfer of digitally represented assets or information over a peer-to-peer network[6]. They operate via an innovative combination of distributed consensus protocols, cryptography, and in-built economic incentives based on game theory.

Figure 1: Blockchain Characteristics



Source: http://www.ijmsbr.com/Volume%206%20Issue%204%20Paper%2019.pdf

Generally, a blockchain, as a distributed database, contains the history of all the exchanges between its users since its creation. This database is secure and distributed: it is shared by its various users, without intermediary, which allows each one to check the validity of the chain. Blockchains represent certain innovative properties which make them a highly useful tool in structuring the global economy, including:

- **distributed consensus** – no central point of control or failure (no checkpoints or intermediaries);

[5] Ateniese G, Faonio A, Magri B, de Medeiros B. Certified Bitcoins. In: Boureanu I, Owesarski P, Vaudenay S, editors. Applied Cryptography and Network Security. vol. 8479 of Lecture Notes in Computer Science. Springer International Publishing; 2014. p. 80–96.

[6] For more detailed descriptions see, e.g.: https://en.wikipedia.org/wiki/Blockchain_%28database%29; Gian Volpicelli, 'Beyond Bitcoin. Your Life is Destined for the Blockchain', Wired Magazine (7 June 2016), at: http://www.wired.co.uk/article/future-of-the-blockchain; and 'Blockchains: The Great Chain of Being Sure About Things', The Economist (31 Oct 2015), at: http://www.economist.com/news/briefing/21677228-technology-behind-bitcoin-lets-people-who-do-not-know-or-trust-each-other-build-dependable

- **transaction transparency/auditability** – every ledger entry is verifiable and retraceable across its full history (accountability);
- **party identity abstraction** – individual parties can transact with one another across the network without revealing their full identities (enhanced privacy).

Box 1: Principles of Blockchain Technology

There are five basic principles underlying the blockchain technology[7], namely,

- the *distributed database* enabling everyone to have access to the entire database and its complete history;
- *peer-to-peer transmission* in which communication directly occurs between peers rather than through a central node*;*
- *transparency* Every transaction and its associated value are visible to anyone with access to the system. Each node, or user, on a blockchain has a unique 30-plus-character alphanumeric address that identifies it. Users can choose to remain anonymous or provide proof of their identity to others. Transactions occur between blockchain addresses.
- *irreversibility of records* that once a transaction is entered in the database and accounts updated, the records cannot be altered as they are linked to every transaction record that came before them (hence the term 'chain'); and
- *computational logic* in that users can set up algorithms and rules that automatically triggers transactions between nodes.

Source*: IoT and Blockchain: Challenges and Risks: https://ahmedbanafa.blogspot.in/2017/?view=classic*

These are some of the properties that blockchains are often referred to as the 'Internet of Value'. In this context, blockchains allow individuals and organizations to exchange value (e.g. money, or assets, or assets for money) across borders in the same way the internet allows us to exchange information on a global, decentralized, peer-to-peer basis. And much like exchanging information on the internet, exchanging value on a blockchain is fast and cheap – often considerably faster and cheaper than the existing "legacy" systems of the global financial order.

2.2 Types of Blockchain

Blockchain can be established on two major categories: the public blockchains, open to everyone (Bitcoin, Ethereum, Tezos, etc.), and on the blockchains companies (Hyperledger, Ripple, MultiChain, etc.). Private blockchain accessible only by authorized and known users. The participants of the network are able to add data records to this ledger using a private key or public key cryptography[8]. They can also be configured to accommodate greater or lesser degrees of user

[7] The Truth about Blockchain. *By Marco Lansiti and Karim Lakhany, Harvard Business Review.*

[8] Spagnuolo M, Maggi F, Zanero S. BitIodine: Extracting Intelligence from the Bitcoin Network. In: Christin N, Safavi-Naini R, editors. Financial Cryptography and Data Security. vol. 8437 of Lecture Notes in

privacy. In the blockchain, there is no role of the third party to identify and manage data or participant.

Table 1: Private / Public Blockchain Distinction

	Public Blockchain	Private Blockchain
Accessibility	Access to everyone	Access to members of the network only
Security	More users there are, more security of the blockchain is ensured	Only the validating nodes are authorized to validate a transaction
Operation	Validation of blocks by anonymous participants according to the Proof-of-Work (PoW) consensus protocol	Identification and prior authorization from the participants to validate the blocks
Confidentiality	Access to data are transparent. In principle, the holders of addresses are anonymous	Only the authorized actors of the blockchain have access to data and transactions
Feature	High cost due to power of the various minors	Lower transaction cost because of the reduced number of minors (less energy consumption, less computing power ...)

2.3 Bitcoin

The first blockchain ever developed is the cryptocurrency known as Bitcoin[9] - a Peer-to-Peer Electronic Cash System– a non-state form of digital money that went into circulation in 2009 and has since achieved considerable success. Indeed, the bitcoin uses blockchain technology, which has led to the blockchain / bitcoin amalgam. However, bitcoin is a cryptocurrency and the blockchain is a protocol on which the operation of this cryptocurrency is based. Bitcoin allows for online payments between parties without the need of a financial institution[10] .

Computer Science. Springer Berlin Heidelberg; 2014. p. 457–468. Available from: http://dx.doi.org/10.1007/978-3-662-45472-5_29

[9] https://bitcoin.org/bitcoin.pdf

[10] Satoshi Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System", https://bitcoin.org/bitcoin.pdf

Box 2: Bitcoin

Bitcoin the Platform has four key distinct characteristics.

1. **Bitcoin the blockchain**, which is the open ledger maintained and safeguarded by the distributed network of miners.

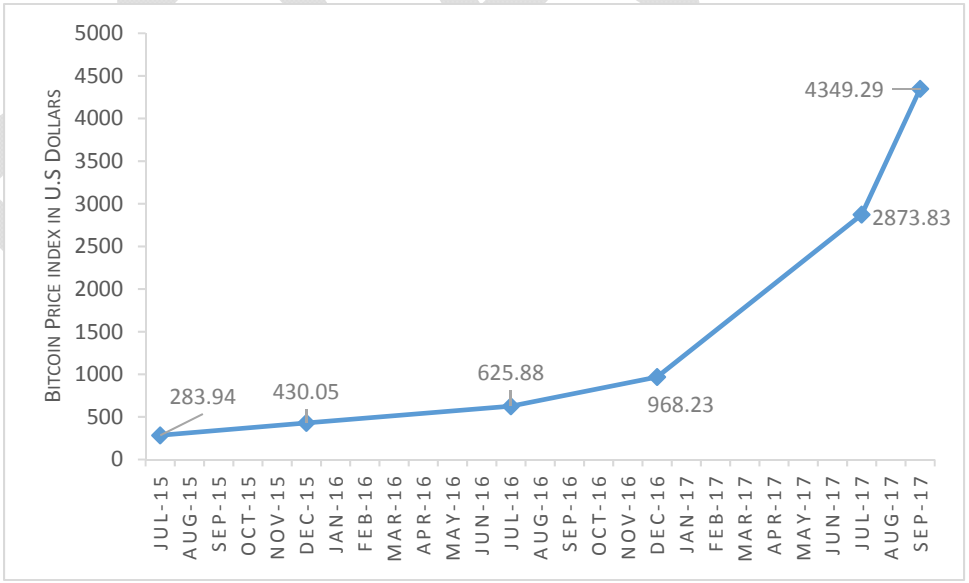
2. **Bitcoin the currency**, which is the digital token used for transactions and to reward miners who safeguard the network and blockchain.

3. **Bitcoin the payment network/protocol,** that is used to carry bitcoin currency transactions across the network.

4. **Bitcoin the software**, that is open source and allows for extensible and evolution of the platform in the future.

Its diffusion and capitalization make bitcoin the most important virtual currencies created at this day. Indeed, at its launch in February 2009, a bitcoin cost just a few cents, and even at the beginning of 2017, it was only $ 966. Since then, this self-regulating virtual currency has steadily increased its price to reach US $ 5.247 in October 2017.

Figure 2: Bitcoin price index July 2015 -September 2017

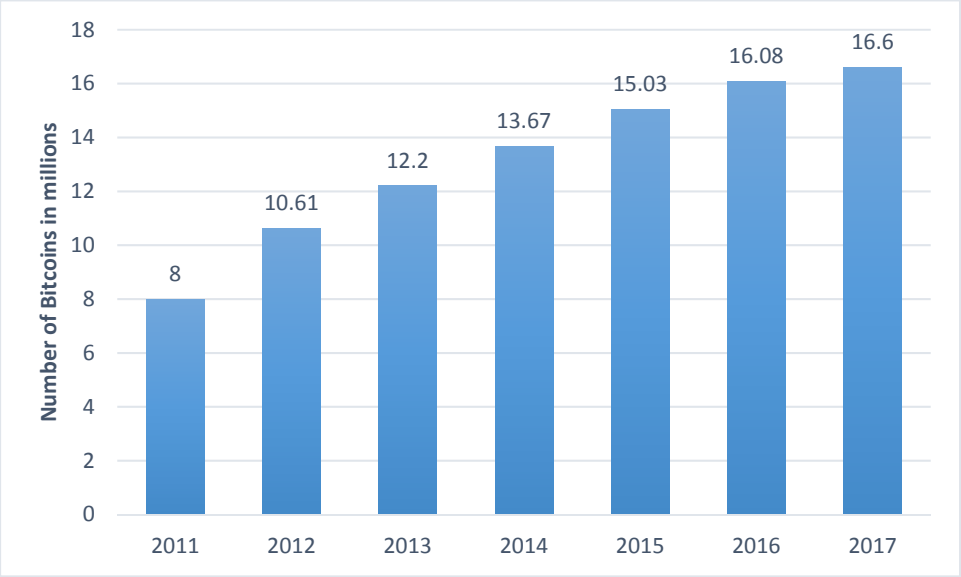


Source : https://www.statista.com/statistics/

In September 2017, the capitalization of bitcoin was estimated at 69.871 billion dollars (47.3% of the cryptocurrency market) followed respectively by Ethereum, with a capitalization of 28.28 billion dollars, Bitcoin Cash with a capitalization of 8.587 billion dollars, Ripple (8.298 billion) and Litecoin (3.488 billion). However, Bitcoin also faced scrutiny from law enforcement. For instance, in September 2017, the currency has fallen 40% after announcement of a crackdown on the digital currency from China who accounts more than 60% of all bitcoin trade.

As a means of payment, Bitcoin is being accepted by a growing number of merchants, prompted by transaction fees that are generally less than the 2-3% charged by credit card organizations. For the Bitcoin system, the amount of the transaction ranges between 0 and 2%. Unlike credit cards, the potential costs are charged to the buyer (not the seller). Bitcoins is also not issued by a central and regulated body, but created in a decentralized way in participating miners' computers to the network A bitcoin transaction is irrevocable and cannot be cancelled. As a result, the number of Bitcoins has been growing since the creation of this virtual currency in 2009 and reached approximately 16.6 million in September 2017.

Figure 3: Number of Bitcoins in circulation worldwide from 1st quarter 2011 to 3rd quarter 2017



Source : https://www.statista.com/statistics

2.4 The Ethereum blockchain

The Ethereum blockchain has become as popular as bitcoin. Created in 2014, Ethereum also uses its own cryptocurrency: Ether. Its price is lower (about $ 300 in October 2017) than that of bitcoin but its capitalization reached $ 28.5 billion in October 2017. Unlike bitcoin, which allows only simple transactions (mainly payments), Ethereum goes further. It makes it possible to run "smart contracts", autonomous programs that automatically execute actions validated beforehand by the stakeholders. Ethereum and these smart contracts are of interest to banking and insurance players as well as the legal professions. In the future, these players will be able to certify property transfers more securely or automatically pay compensation. For example, the french Insurance Gian Axa SA[11] was the first insurer utilizes the Ethereum blockchain to manage insurance contracts and to process payments. In September 2017, he launched an automated insurance for flight delays. Based on the Ethereum blockchain, this insurance is actually a "smart contract" linked into global air traffic databases that triggers an automatic refund once the delay of more than two hours has been found.

3. Use and Potential Applications of Blockchain Technology

Blockchain technology applications are very numerous and are likely to reorganize the entire sectors of the economy. While initially the blockchain was developed to serve as a monetary support (bitcoin), today offers opportunities for multiple uses mainly because of its advantages, including decentralization, security and transparency. The potential use cases are limitlessness. Beyond non-state cryptocurrencies, blockchains can be used to represent, track and trade many other types of assets as well, which include government issued money; stocks, bonds, options, derivatives, and other financial products; real and intellectual property rights; contract rights; the movement of goods and services across a global supply chain; and the expenditure of public or private funds; and much more. Finally, as a technology referred to as ‘the Internet of Value’, blockchains also enable integrating with other emerging technologies such as the Internet of Things (IoT), Big Data, cloud computing, Artificial Intelligence (IA), robotics, additive manufacturing, new materials, augmented reality, nanotechnology and biotechnology. By 2019, 20% of all IoT deployments will have basic levels of blockchain services enabled (IDC-2017)[12]

Although the adoption in the sector is yet to be seen, blockchains are also rapidly becoming the bedrock of the ‘New Industrial Revolution’ (Industry 4.0) – introducing provenance tracking, identity management, and digital scarcity into global supply chain management while also

[11] https://siliconangle.com/blog/2017/09/13/axa-utilizes-ethereum-blockchain-new-flight-delay-insurance-product/

[12] https://www.i-scoop.eu/digital-transformation-major-wake-call-2017-beyond/

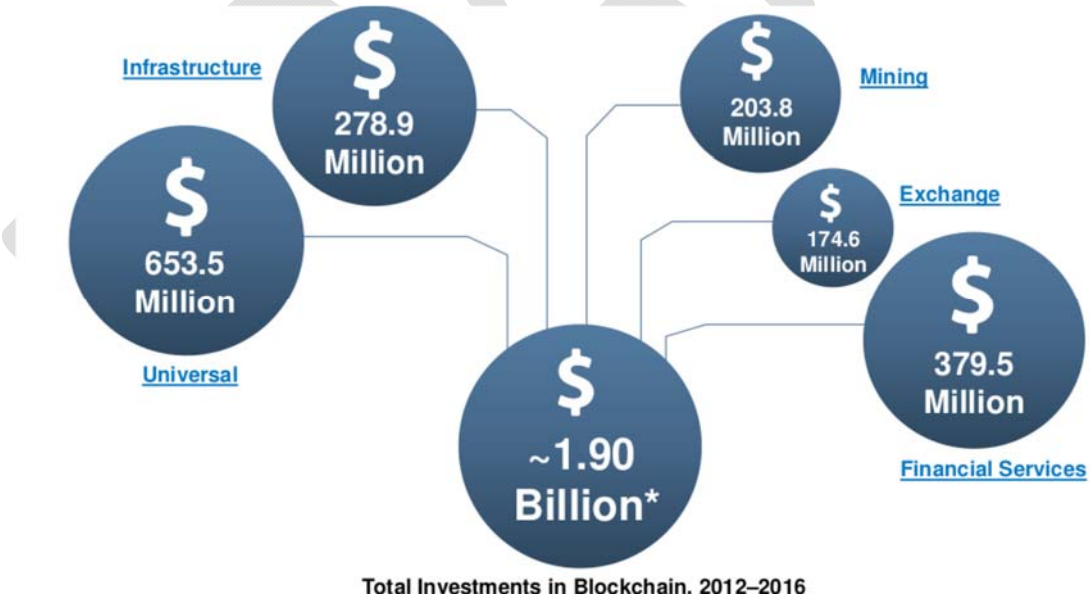
enabling the near real-time trade and settlement of both tangible and intangible assets over secure, distributed networks.

The worldwide blockchain market has grown strongly in recent years. As shown in figure 3 below, in 2017, the global blockchain technology market is predicted to reach 339.5 million US dollars in size and is forecast to grow to 2.3 billion US dollars (around 61.5% CAGR) by 2021. While the amount total investment in the sector was $ 694 million US dollars as of June 30, 2017.

The use of the blockchain can be classified into three categories:

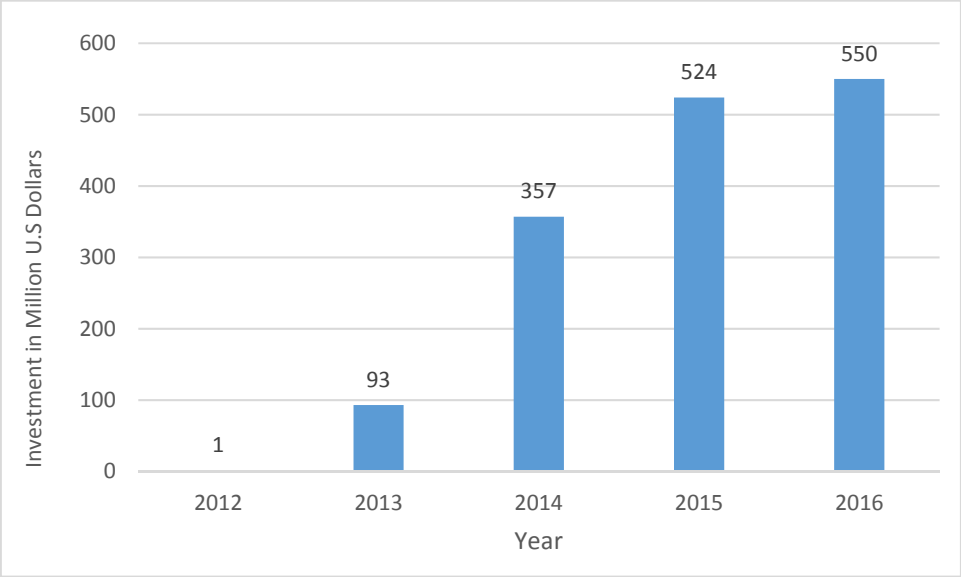
- Applications for the transfer of assets (currency, securities (shares, bonds, derivatives, etc.)) votes, etc.)
- Applications of the blockchain as a register: this ensures better traceability of products and assets.
- Smart contracts: these are stand-alone programs that automatically execute the terms and conditions of a contract without requiring human intervention once started.

Figure 4: Total Investments by sector in Blockchain, 2012-2016



Source : https://www.statista.com/statistics/

Figure 5: Blockchain Investment 2012-2016



Finance Sector: Blockchain technologies are being deployed to replace single points of financial system failure with decentralised market structures. They are helping expand financial inclusion to the estimated 2 billion unbanked population who are currently not being served by the global financial system. As a result, recent venture capital developments indicate that the financial industry is mobilizing around the potential impact of blockchain on their business, and is beginning to invest in related research and development and is testing applications. Investment in blockchain is gaining momentum, with approximately $1 billion of venture capital investment over the last 24 months ($500 million in 50 venture capital deals in 2016 alone) and the trend is expected to grow rapidly[13]. A 2017 McKinsey survey found that the global banking industry is expected to spend $400 million on blockchain related projects by 2019. Some 70 percent of financial organizations are in the early stages of experimentation with the technology and most executives expect to see material impact in mainstreaming it in the next five years. Consequently, a first rough estimate of limited applications, driven mostly from a cost reduction perspective, suggests significant value creation on the order of $70 to $85 billion[14].

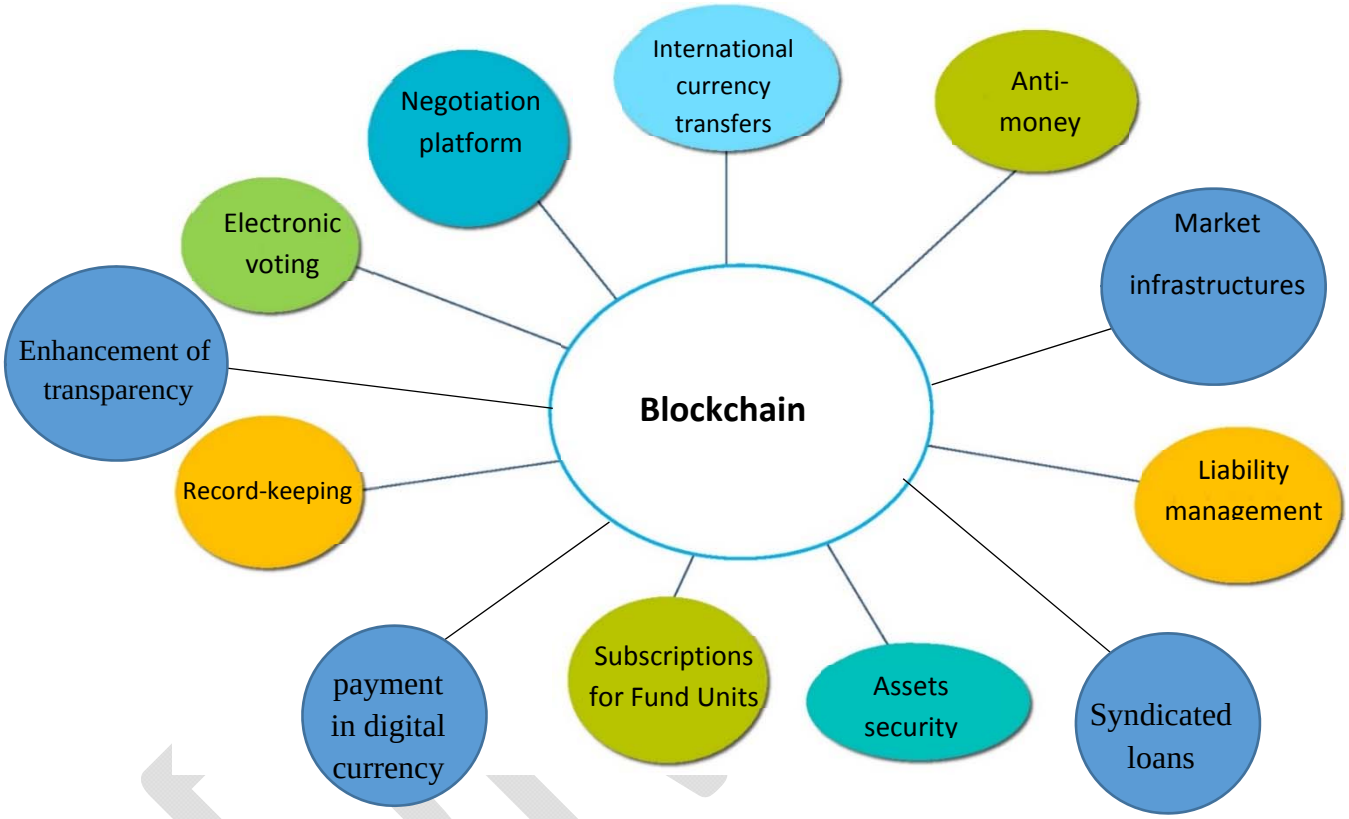
In the finance sector application are:

- Payment:
- Remittance:
- Automate payments

[13] Blockchain in Financial Services in Emerging Markets Part I: Current Trends. *EMCompass – Fresh ideas about Business in Emerging Markets, Note 43, August 2017; IFC.* www.ifc.org/ThoughtLeadership
[14] McKinsey. 2017. "Blockchain Technology in the Insurance Sector - Quarterly Meeting of the Federal Advisory Committee on Insurance (FACI)." McKinsey & Company Report

- Crowdfunding: enhancement of transparency
- Crowd lending:
- Micro-payments:
- Tips and donation:

Figure 6: Use case in the banking and financial industry



Box 3: IBM Announces Major Blockchain Solution to Speed Global Payments

IBM announced a new blockchain banking solution that will help financial institutions address the processes of universal cross-border payments, designed to reduce the settlement time and lower the cost of completing global payments for businesses and consumers. Using IBM Blockchain, and in collaboration with technology partners Stellar.org and KlickEx Group, the solution is intended to improve the speed in which banks both clear and settle payment transactions on a single network in near real time. The solution is already in operation on 12 currencies between the Pacific Islands, Australia, New Zealand and the United Kingdom. A little more than a dozen banks are part of the initial program to be developed towards South America and South-East Asia in 2018

Source: IBM : http://www-03.ibm.com/press/us/en/pressrelease/53290.wss

It is believed that blockchain can enable build an inclusive, transparent, and accountable digital economy for all[15]. Blockchains are being deployed to replace single points of financial system failure with decentralised market structures. They are helping expand financial inclusion to the estimated 2 billion unbanked population who are currently not being served by the global financial system.

Education: Blockchain can be implemented within individual or group of educational institutions both at national and international level. It can enable anyone to be able to securely store badges, credits, and qualifications which make educational data available to others. As education becomes more diversified, democratised, decentralised and disintermediated, and as we need to maintain reputation, trust in certification, and proof of learning. Blockchain has the potential that could provide a system – a massive open, online, secure database that educational systems need particularly. For instance, Universities in Malta and Australia are developing a system for issuing and maintaining degrees on a blockchain. There are also some universities (Switzerland, United Kingdom, USA etc.) that offer an inscription payable in Bitcoin and others provide training courses on the Blockchain. For example, as of mid-October 2017 , more than one hundred students of the Massachusetts Institute of Technology (MIT) will have a copy of their diploma stored on Blockchain. In Russia, many universities have included this year a "cryptocurrency & blockchain" curriculum in their finance programs.

Land Management: Governments generally maintain the records of who owns a certain piece of land or property while the actual owner might not have a piece of information or paper to prove ownership. There could also be a risk of records being lost, manipulated or a deed could also be issued for someone else for the same property. Given that blockchain can serve as a tool to determine who owns what, it could solve this kind of problem. The information can be securely stored on the ledger and prove which parties are involved and what they agreed on. Being documented on decentralised network, this information cannot be forged and any transfers of the property ownership maintain transparency in the network. As a building block for any economy, without transparency, land cannot be bought or sold freely and will not be put to its highest and best economic use. In this regard, for example, Sweden, Georgia and Ukraine[16] property registers are being moved on to the blockchain.

[15] Julie Maupin (2017). The G20 countries should engage with blockchain technologies to build an inclusive, transparent, and accountable digital economy for all. *Economics: The Open-Access, Open-Assessment E-Journal, Discussion Paper, No. 2017-48, August 01, 2017*. http://www.economics-ejournal.org/economics/discussionpapers/2017-48

[16] See also https://www.newamerica.org/international-security/future-property-rights/blog/will-blockchain-work-ukraine/

Law: The blockchain technology enables smart contracts. Smart contract or intelligent contract is a set of promises, specified in digital form that relies on blockchain technology to make their terms and conditions of execution unfalsifiable. Due to the smart contract, contracts, conditions, transfers of ownership and delivery of goods or services are traced without the need for a trusted third party. To this end, for example Ethereum-based smart contracts help to automate the process

Governance : Blockchain technology has a stake in the management and security of citizens' data (identities, criminal history, etc.). It can greatly help to improve the democratic process in several countries through two major axes: secure online voting system and control of public expenditure. Blockchain technology could improve transparency and check corruption in governments worldwide. Furthermore some blockchain-based applications, like for example Boardroom, enables organisational decision-making to happen on the blockchain. In practice, this makes company governance to become fully transparent and verifiable when managing digital assets, equity or information.

Health: Blockchain technology has the potential to address the interoperability challenges currently present in health IT systems.Medical records can be stored on a blockchain. They are easily accessible and continuously updated to facilitate the physician's work, increase patient care and reduce the time to transfer medical records.

Energy: Blockchain has disruptive potential for the energy industry. Blockchain is used to decentralize the distribution, sale and transfer of energy through micro-transactions of data sent to the system, validated and re-transferred to the contributor's network secure payment.

Supply Chain: With the blockchain, companies make supply chains, shipments and deliveries completely transparent. By using the blockchain, companies will benefit from more trust for users.

Travel: Blockchain allows loyalty programs to be managed transparently for the customers and streamlined for the company. It also provides a reliable and automated system for on-line booking as well as identity or insurance management

Food: In food, blockchain technology is at the service of the traceability of the product. It makes possible to know in particular the information such as the origin, storage and expiration date of the product in a totally reliable manner.

Insurance: Intelligent contracts, or self-executing contracts, have emerged with this technology, more precisely thanks to the Ethereum network. These stand-alone programs execute automatically the terms of a contract, without human intervention, based on reliable data sources capable of providing the required information. Stand-alone vehicles or other intelligent devices can communicate their updates status to the insurance providers through the blockchain to avoid misrepresentation

4. Potential applications of blockchain technologies in Africa

In Africa, adoption of Blockchain technologies suggests many prospects for use that could upset whole sectors of the economy. This technology, particularly attractive to traditional financial institutions and entrepreneurs, makes financial services available to more Africans and reduces counterparty risk. For example, in South Africa, Ghana, Kenya, traditional banking institutions invest heavily and collaborate to develop blockchain technology and explore its new possible implementations. However, in Africa, there are very few concrete cases of the use of or adoption of blockchain technology. Solutions are developed within the constraints of a poor understanding and knowledge of the technology, especially in sectors other than banking. But some applications using blockchain technology have been developed in the continent. Among them:

- online payment systems for fast growing e-commerce across Africa
- International money transfer system, between African diaspora and their countries.
- Land security system (cadastral management), already being tested in some African countries
- System for combating counterfeit medicines that decimates our poorest populations
- System of traceability of the different raw materials and other mining products of our country (secure route, identifying and reliable actors, removal of intermediaries not indispensable, etc.)
- Copyright management system
- System for the attribution and monitoring of public procurement

In the following section, we will highlight some of the potential applications of blockchain technologies in selected areas, namely, finance, education, health, land and governance.

e-Dinar, première monnaie à adopter la blockchain : La Poste Tunisienne launched in October 2015 blockchain experimentations in partnership with the Tunisian FinTech startup migration of the Tunisian national currency into the bloc chain (a public ledger of bitcoins transactions made as Monetas). Monetas software uses the cheapest transaction platform, which is interoperable across mobile networks (http://futureism.com; ITU 2017). Varieties of transfers are facilitated through smartphones. Notably, they include instant money transfer using, online and in-person payments for goods and services, remittances, bills and salaries and debt collection. Early success has led to increasing numbers of subscribers, who were estimate at 520000 in March 2017, and increasing numbers of annual transactions, reaching approximately 2.5 million per year (ITU 2017). Block chain is generating e new stream of revenues.

Adoption of block chain by African Banks: **:** the importance of cryptocurrencies such as bitcoin or ethereum is that they remove the need for the trusted third party, using instead an encrypted, secure database. This has huge implications for any business that requires the verification of payments and performance of contracts – that is, most businesses. In this regard, Banks also use blockchain based platforms for government bond settlements. For instance, six

large banks in South Africa, BSA, Frist National Rand, Investec, Nedbank, Standard Bank and the South African Reserve Bank have adopted a private block chain technology (distributed ledger) to facilitate electronic settlement of equities and bond transactions made at the Johannesburg Stock Exchange. Another benefit would be to make micropayments possible digitally. Exchange of assets is now faster and at lower costs. A number of leading financial institutions are contemplating to replicate this model[17] . It is expected that block chain will help to raise additional revenue streams.

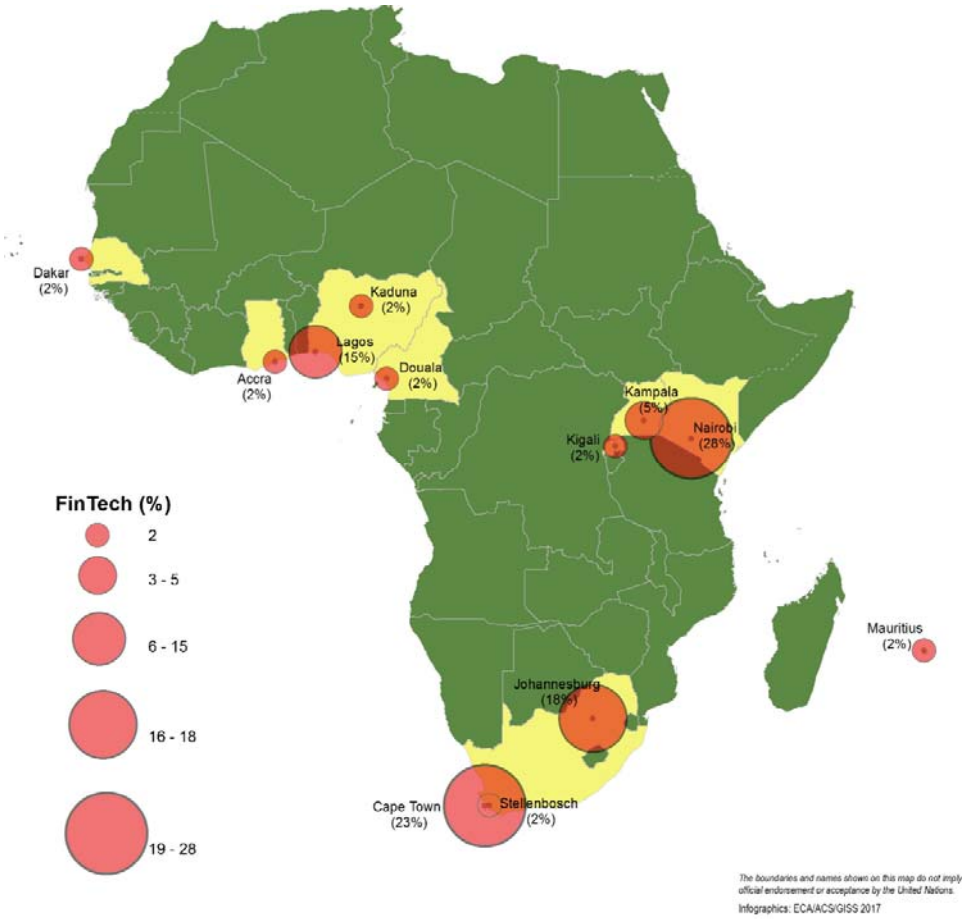
Remittance: BitPesa – The use of cryptocurrencies can significantly reduce, if not eliminate, the high transaction costs of remittance payments, encouraging further capital flows to African countries most in need. Africa's leading Bitcoin start-up, BitPesa, has already proved this to be true. Founded in 2013 , BitPesa , a Kenyan platform for digital currency payments, provides an online platform to convert digital currency, such as Bitcoin, into local African currencies.. BitPesa sends and collects disbursements within Africa and between Africa and the rest of the world. It facilitates global imports and exports. BitPesa has managed to raise $6 million in 2017. Today, it operates in Nigeria, Senegal, DRC, Uganda, Tanzania and Kenya. It has plans to expand its services across West and Southern Africa as well as in Europe in the future (https://disrupt-africa.com.

Fintech: In the last couple of years, Africa saw a boom in fintech startups across the continent. According to the Finnovating for Africa Exploring the African Fintech Startup Ecosystem Report 2017 released by Disrupt Africa, there are 301 African fintech startups currently active. The data spread across the African continent, with the Southern, West and East African regions equally active, while North Africa lags behind. Among the countries, South Africa leads as the top destination for fintechstartup activity hosting 31.2 per cent of the continent's fintechstartups while Nigeria and Kenya follow in the second and third place respectively[18].

[17] http://wwwww.iweb.co.za

[18] See also http://disrupt-africa.com/finnovating-for-africa/

Figure 7: 63 Fintech Companies in Africa



Further, a number of countries have also emerged as a vibrant destination for fintech destinations, particularly in the west Africa where Ghana and Cameroon are increasingly prominent markets. Among the nine fintech categories considered in the report, payments and remittances startups dominate the market, with 41.5 per cent of all startups focused on this space. While lending and financing services also prove a popular priority for Africa's fintech innovators.

Land Management : In Africa, the lack of a reliable a nationwide land and property register is a major economic obstacle to the development of the continent. Indeed, in the majority of African states, more than 90% of the rural areas are not listed. Technologies like Ethereum can revolutionise land ownership in Africa through the creation of virtual land and property registers via securing properties with private contracts written in a public form and protected by strong encryption technologies. In this regards, recognising the potential benefit, some countries have begun implementing blockchain for land and property administration. For example, initiatives in this respect have begun in Ghana where blockchain are being used for land registration.

Nearly 90% of Ghana's rural land is not registered in an official database, and many citizens do

not yet have an official address. This initiative in Ghana, named Bitland, seeks to give African land titles the credibility they currently lack. Similarly in other parts of the world, blockchain attracts interest for use in property administration

Box 4: Bitland – A Ghanaian non-profit organization registering land and real property ownership using block chain technologies

Bitland – A Ghanaian non-profit organization registering land and real property ownership using block chain technologies. Using block chain technologies, Bitland aims to facilitate the recording of all transactions on distributed ledgers, increasing transparency and efficiency in land registration processes, and improving revenue collected by government. Started in Kumasi (Ghana), Bitland has plans to expand its experience to the rest of African countries in the near future. Bitland has allotted in the first year of operation, 20 million cadastrals (token currency) for use through the Crypto Currency Exchange Denmark (Bitland 2016). Prices will increase from Satoshi 10,000 (approx. $0.04) in phase 1, to Satoshi 30,000 (approx. $0.12) in phase2.

Bitland is also a community-centered entity. It has an education plan, designed to inform communities about the benefits of Block chain technologies in their country. It is thus a useful engine that engages and empower local communities, in addition to its major goal of enhancing efficiency in land registration, real property ownership, use of, and access to, rights, and information. According to estimates in 2016, suggest that Bitland will help to free up trillions of dollars that will support infrastructure development plans (https://www.forbes.com).

Transport: In the transport sector in Kenya, the National Transport Safety Authority (NTSA)'s new service running on a shared BT platform will link various State agencies from the Kenya Revenue Authority and Kenya Police promptly alerting security officers about a vehicle's insurance and inspection status as well as ownership. Recently, the National Transport and Safety Authority (NTSA) has disclosed, Kenya will have an electronic motor vehicle identification service where all vehicles will have an electronic sticker pasted on the windscreens detectable via use of special gadgets thereby helping root out jalopies from Kenyan roads and recovery of stolen vehicles.

Health: Kenya's public health sector is installing a smart platform in all 98 public hospitals creating a shared BT hub where crucial data such as a patient's history, hospital management and

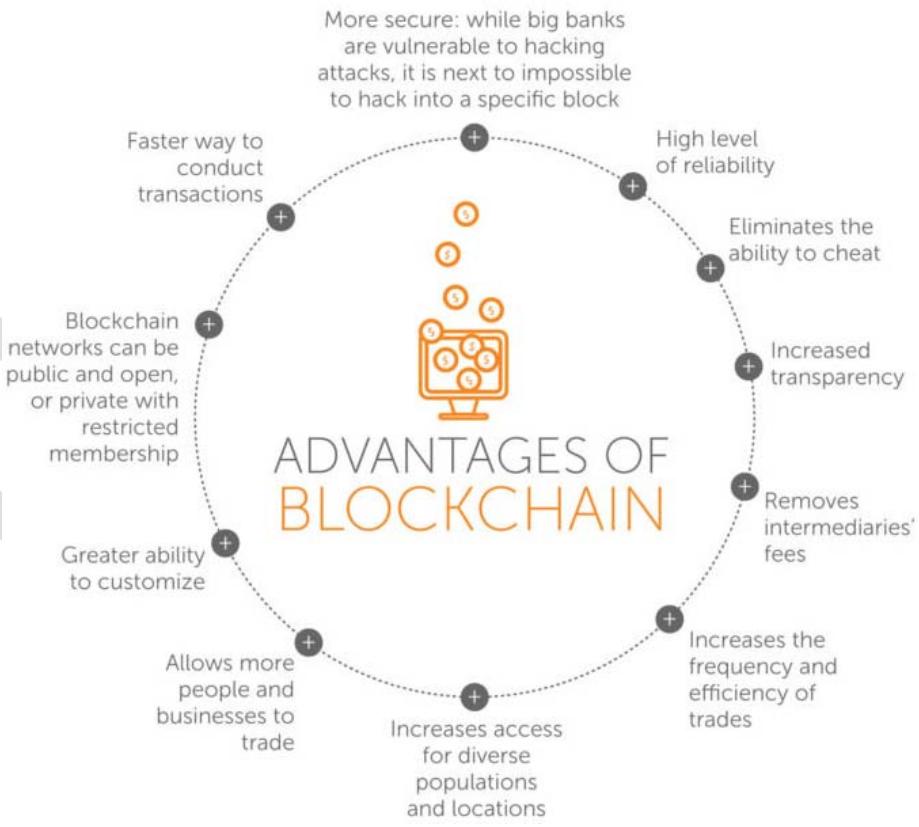
use of public resources will be monitored from the cloud-based database Kenya is partnering with the World Bank to look into the issuance of blockchain-based government bonds.

Education: In Nigeria, the blockchain industry has received a boost as government agencies are collaborating with Cryptography Development Initiative of Nigeria (CDIN) in education and implementation of the technology.

5. Benefits of blockchain technologies in Africa

Some literature on blockchain technologies, and Bitcoin, emphasize their vast potentials to revolutionize economies and improve societies. As show in the figure 6 below, based on their technical features, distributed consensus, blockchain technologies and Bitcoin can enhance efficiency in almost all economic sectors, ranging from Agriculture, forestry and fisheries, Mining and quarrying, Manufacturing, Electricity, gas and water supply, Financial intermediation, Public administration & defense, Hotels & restaurants to Transport, storage & communications.

Figure 8: Blockchain advantages



Source : http://www.arreverie.com/blogs/blockchain-technology-everything-need-know/

The potential of Blockchain to boost revenues in unprecedented manner across such sectors can be reflected by considering for example growth of market share of Bitcoin (that uses Blockchain). In the U.S., where the average market price of Bitcoin was up 1,600% only between October 2015 and October 201719. In Japan, investment in Bitcoin is rising at unprecedented rates. In India, the users of Bitcoin reached about 1 billion in 2017. Worldwide, States are now starting to adopt Bitcoin currency, and proliferation of investment in the virtual currency is on skyrocketing.

In this regard, blockchain can provide enormous potential for a variety of application areas and bring a range of benefits to the users particularly as widely written more beneficial to developing and emerging markets such as those countries in Africa. The section below focuses on economic sectors, where the blockchain technologies have demonstrated significant impacts, beyond the technical or scientific potentials at national, regional and/or international levels.

- ***Facilitating cross-border transactions:*** Variations in currencies, legal systems and exchange rates, make financial transactions among African countries difficult and cost-ineffective. Such transactions are however much easier between Africa and and Europe, and/or the U.S.. Blockchain provides a solution to this problem, by increasing speed, transparency and reducing or clearing out such variations in such transaction and making them efficient. As a result, Blochchain enables, for example, flows of assets across borders and between institutions at the lowest rate. Blockchain technology is thus very helpful in enhancing the regional integration plan of Africa, rationalising the global supply chain and trade.

- ***Reduced the high cost of remittance payment:*** In finance, if people want to lend to each other, they had to go through an intermediary such as banks. However, in Africa, sending cash via traditional remittance companies is a long and costly process and some international remittance agencies charge as much as 10% to 12% of monies being remitted via their system. Bank wire transfers are even more expensive, with fees of 10 to 15 percent[20]. In this regard, the importance of cryptocurrencies such as bitcoin or ethereum is that they remove the need for the trusted third party, using instead an encrypted, secure database. A good example of the potential benefit of blockchain in the financial sector could be in remittance payment which is a vital source of income for a number of African countries. Nigeria, according to the World Bank is Africa's largest recipient of remittance with an estimated USD $19 billion followed closely by Egypt with USD $ 16.5 billion annually. It is therefore recognised that the cryptocurrencies can significantly reduce, if not eliminate, the high costs of transaction of remittance payments, and on the other hand encouraging further capital flows to African countries most in need. BitPesa, Kenya's first blockchain application proved this and provides an online platform to covert digital

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[20] "Distributed Ledger Technology (DLT) and Blockchain." FinTech Note Series, forth-coming publication from World Bank Group.

currency, into local African currencies. It is noted by the Chief Executive of BitPesa that Bitcoin-based remittance services have reduced the costs of international payments by 75%, and reduced the average time settlement from 12 days to approximately 12 hours[21].

- ***Enabling access to financial services:*** In Africa this technology is particularly appealing as it will make financial services available to a greater number of Africans (approximately 80% of which are currently unbanked according to the World Bank (reference). Blockchain and its applications can provide financial services to all levels of society and bring affordable financial services to low income countries. Given that only one third of adults in Sub Saharan Africa has access to some kind of financial service, in order to ensure financial inclusion in the continent, blockchain could bring access to banking to millions of poor people, helping them to save and plan for their future[22].

- ***Access to the credit*****:** Given that many African economies depend to a large extent on the success of local Small and Medium Enterprises (SMEs) that receive financial support they need to grow, blockchain could be particularly beneficial by facilitating better credit to small businesses through smart contracts and negate settlement times and in return reducing costs to almost zero. Blockchains don't only favour small businesses they do also benefit larger businesses too, by saving time and money on processes such as payment collection

- ***Ensuring privacy*** : Blockchain technology has the ability to increase secure data exchange in other industries as well. In this regard, the online marketing and advertising industry has feasted on data generated by internet users, and social media platforms, etc. that enable them collect considerable amounts of individualised data on users to target adverts at them. Blockchain could enhance online privacy, by allowing users to store their digital footprint on their own unique blockchain and control who has access to it. Rather than these massive organisations building up records of users' tastes and preferences, this data would be decentralised and within their own control. Online privacy would be enhanced with blockchain, as individuals would have secure control over their own personal data[23].

- ***Job creation***: Given the low level of the financial system in the continent compared to the developed world, blockchain and cryptocurrency adoption would be more suited in the continent due to the many different currencies and the under-developed payment system. The deployment of bitcoin as a common currency on the African continent will open doors for job creation in several industries. This will lead to rapid investments since movement

[21]Digital currency could spark African financial revolution. HeleenGoussard, August 2017

[22] Ibid 20

[23] Gowers, Rob and Aminoff, Jukka (2017). The big business revolution: why the future is blockchain. Anglia Ruskin University.

of capital is slow when considering traditional channels as well as to bost a demand for African product since the payment part and (possible fraud) will be sorted[24]

- ***Improve good governance:*** In enhancing good governance, blockchain can also be applied a number of areas. Whilst substantial advances have been made in the continent, governance is the biggest challenge to successfully doing business in Africa. Blockchain technology could improve transparency and check corruption in governments. Trust in institutions is still low compared to many places across the globe and this stifles the potential foreign direct investment and internal efficiency in providing effective public services. Furthermore, according to the ECA African Governance report[25], released in 2016, that stated that corruption is a major impediment to African growth and that illicit flows of capital are finding it easy to avoid detection, blockchain has a paramount importance in enhancing governance across all socio-economic sectors. In elections, blockchain has a very important application by making the results fully transparent and publicly accessible in that distributed database technology could bring full transparency to elections or any other kind of poll taking[26].

- ***Access to the market*** : By removing barriers, such as intermediary banks, large amounts of costs, interminable waiting periods, and regulatory restrictions including service providers connecting with the blockchain technology can open up financial systems to entire countries and global market become more accessible to investors and issuers. Furthermore, the parties will be able to develop direct communication without the need of intermediaries and the overall chain will become lighter

- ***Improved business environment:*** Given that many African economies depend to a large extent on the success of local Small and Medium Enterprises (SMEs) that receive financial support they need to grow, blockchain could be particularly beneficial by facilitating better credit to small businesses through smart contracts and negate settlement times and in return reducing costs to almost zero. Blockchains don't only favour small businesses they do also benefit larger businesses too, by saving time and money on processes such as payment collection[27].

[24] Ibid 22
[25] https://www.uneca.org/sites/default/files/PublicationFiles/agr4_eng_fin_web_11april.pdf
[26] Ibid 24
[27] Ibid 24

6. Africa's challenges for blockchain solutions in addressing the continents' social, political and economic problems

In Africa, compared to other parts of the world, in many areas there is a lack of extensive infrastructure, advanced financial institutions, a high degree of political stability and/or large pools of capital. As an evolving technology, in Africa too, the distributed ledger technology will face numerous challenges mainly in three aspects – technical, regulatory and institutional, as the technology moves towards maturity. In addition, at institutional level, there is a lot of resistance on the deployment of blockchain in the last few years of blockchain thriving into the market in a number of countries.

- **Technological issues:** While blockchain technology development is progressing rapidly, there are still a few technological challenges that remain to be addressed if these technologies are to be adopted by the intended users. some of the challenges include:
    a) scalability and transaction speed of distributed ledger systems, for permissionless blockchains such as bitcoin
    b) the interoperability of different ledgers and those with the existing legacy systems and transition costs;
    c) network security and resilience of the system against potential cyberattacks (a recent setback for Ethereum);
    d) the protection of data privacy.

- **Infrastructures**: Infrastructure is key challenge given the low level of connectivity which represent only about 23 per cent of individual households having the internet access by end of 2016 (ITU_Facts & Figures 2016) In addition, the proportion of people online is still far behind the global average – 17.4% of individuals have access to mobile broadband, while fixed broadband connections remain very low. As blockchain applications runs on the Internet, access to the internet would be critical for widespread use of the technology.

- **Energy consumption**: Most important challenge is that the energy consumed in computational capability in the blockchain network is unsustainable. For example, Bitcoin network would today consume between 300 MW and 10 GW, or more or less the electricity consumption of Ireland (3 GW). The Bitcoin blockchain alone would consume 100 times the power used by all of Google's servers. The global money supply in circulation today is estimated at $11 trillion. The corresponding energy consumption should therefore be more than 4000 GW, ie 8 times the electricity consumption of France and twice that of the United States. Given that, across the continent, more than half of the 54 African countries have an electrification rate less than 20%, and electricity produced in Africa is very costly for

households, there a need to improve energy access in Africa te get full benefices of blockchain technologies.

- ***Regulation***: The other most important challenge is the legal and regulatory environment. The market situations require the coexistence of both traditional and digital players side by side for some time in order to build bridges to the broader economy. For example, according to a recent study BitPesa Kenyan start-up, a company providing foreign exchange and business-to-business bitcoin based payment services in Kenya and several African countries, has been able to leverage the existing financial ecosystem by connecting to the M-Pesa money network, a subsidiary of telecom company safari.com and provider of mobile payments and a major incumbent player. Given the unpredictability of the African regulatory environment especially in relation to disruptive technologies, any companies operating in the fintech space on a pan-African basis must comply with complex regulations, which are different between both countries and regions, not to mention a government's willingness to embrace the technology. In addition, many of the blockchain technologies and cryptocurrencies are facing substantial resistance from regulator across the continent either because they are threatened or don't understand the benefits of these new technologies. While cryptocurrencies have self-regulating mechanism, there is still a need for localised frameworks that guide start-ups and organisations using blockchain technology to solve local problems.

- ***Security and confidentiality:*** One of the inherent challenges with blockchain ecosystem is the security and confidentiality issue. Transaction confidentiality is of huge importance for a number of multi-nationals, states and parastatals. The validation by mutual consent of the blockchain, one of blockchain's biggest benefits, may also be its down side, as it would potentially allow competitors to view certain details of each other's transactions if the records are not appropriately anonymised or databases permissioned. This is why there is a concerted effort to keep certain information confidential while still allowing for distributed ledger consensus.

- ***Crime*** – the adoption and use of cryptocurrencies has been associated with money laundering, tax evasion, the financing of terrorism and, of course, the spread of fraudulent schemes whose victims could be the citizens. However, due to the more transparent nature of public blockchains, it makes it easier for illegal activities to be tracked and actors involved be caught and prosecuted accordingly. An example could be where in Kenya, criminals brought to criminal cases in Court where hackers have tried to seek ransom in Bitcoin from holding organisation data for ransom. These hackers were caught because their activities were transparent on the Bitcoin blockchain. It is also another opportunity for developers of cryptocurrency projects that are developing privacy tools to develop ethical frameworks and tools such as moderation, content curation and inbuilt mechanisms such as rating systems that used by their communities to protect vulnerable individuals like children from unwanted exposure.

- ***Skills development***: , the full scale up of blockchain in Africa may be difficult given the difficulty in finding the software developers with the necessary expertise to implement it. the use of the application from installing, using and securing many of its features can be sometimes a lot of work and do require the user to be technically capable. Furthermore, many of these facilities do not work on mobile devices that are the most commonly used devices especially in Africa in that these technologies currently exclude majority of the users who are dependent on mobile devices. Whereas it could be a good opportunity for African developers to adopt user friendly mobile tools that work for and within the local context

Finally, although these challenges seems to have been slowing down the adoption of cryptocurrencies and blockchain technology, the future of decentralised models of trust remains optimistic. However, despite these challenges, the blockchain technology which is based on distributed and decentralised digital ledger, for Africa which relies on the success of SMEs for economic development, it could be the ideal solution to a range of problems. By identifying areas that most helpful to the African context, it will be important for countries to continue exploiting the benefits of this most promising and disruptive technology across the continent[28].

7. Policy considerations and recommendations

The following are some of the policy recommendations for considerations by African policy and decision-makers including other public-private stakeholders.

7.1 Infrastructure

For blockchain based applications to run, users need access to the Internet. With Africa's percentage of individual households with access to the Internet remaining at 20% and that of widespread application of blockchain will be inhibited. To this end, African policy- and decision makers need to enhance their efforts in expanding connectivity among the population particularly ensuring broadband access which is key to facilitate use by people applications that require high bandwidth and quality broadband services.

7.2 Application of blockchain

Blockchain has the potential to transform development and improve the lives of people particularly at grassroots. The blockchain technology has been identified as having useful

[28]Karanje, John Wainaina (2017). Crypto-Finance and the Blockchain Economy in Africa.BitHub: Nairobi, Kenya. www.BitHub.Africa

applications in several areas. The blockchain for social impact ecosystem remains nascent. There is a need to unite the blockchain systems and developers in advanced economies with the people that work with the intractable problems of poverty and inequality in emerging markets. By connecting developers, platforms and people who understand the problems, government and finance, countries need to ensure how blockchain technology can transform development agenda and in particular address some of the pressing problems such as poverty and inequality.

7.3 Financial services

As a new technology and the fact that there is limited funding to support the commercial scaling up of prototypes, it would be helpful to identify successful use cases to scale through some sort of financial and institutional partnerships. Furthermore, the involvement of local financial institutions is paramount importance to mobilise capital for entrepreneurs that face challenges in accessing capital.

7.4 Non-financial sector

Too few governments and international development practitioners are familiar with blockchain and its potential. In order to diffuse, blockchain technology needs to be socialized, and the use cases implemented to show how it applies to real world problems in emerging economies. A wide range of awareness raising activities need to be done by the institution in charge of ICTs among people to spread the knowledge about blockchain.

7.5 Policy and Regulation

African governments need to develop policy guidelines in encouraging industries to utilise the technology to promote expansion by utilising. African Regulators should assess the potential of Blockchain technology to reduce costs and enhance transparency within multiple sectors of the economy. In this regard, the existing ICT policy need to reviewed in the context of this and other emerging new technologies and the necessary regulatory mechanisms need to be in place.

The role and uptake of governments will be important, both from an adoption perspective, as well as the creation and enablement of the policy and regulations environment. Government support for financing is also key, as the process of developing bankable projects has high upfront costs, often difficult for small local entities and communities.

7.6 Skills and human development

For the blockchain technology to spread, the talent pool needs to deepen. One of the challenges and concerns identified for this technology to grow and its application to expand, there needs to be a critical mass of skilled human resources in terms of developers, integrators and administrators that can build and maintain the system this technology will be operating. In this regard, there are a range of training courses increasingly made available to support the demand for using this technology. Academic institutions and ministries in charge of ICTs need to plan skills

and human development strategies to widely produce a critical mass of skilled personnel to address the prevailing blockchain developer shortage. This skills and human development plans could include ranging from certification courses such as cryptocurrency certification to postgraduate level study programmes.

7.7 Implications for public, private and other entities

For the public and private stakeholders, blockchain brings opportunities for investing in new technologies for facilitating public services and diversifying business opportunities. Blockchain enables new forms of finance, including crowdfunding and dynamic funding mechanisms from private finance markets. Tax mechanisms and incentives allow blockchain to encourage the private sector to invest in blockchain, for example, through tax credit schemes where credit flows back to investors if governments are encouraging these mechanisms. This therefore opens up new opportunities for public-private partnership. Furthermore, for the success of this technology in Africa, it requires government leadership to make the necessary investments to enable efficient exploration and use of this technology by the economic players in the continent. There needs to encourage more education and training to build the necessary manpower, and more investment in new startup to support their growth and in return boost the economy.

8. Conclusions

Blockchain technology has the potential to foster innovation and broaden access to banking systems for entire countries and provide greater access to financial services in developing and emerging markets like African continent.

Many of the countries in Africa are off the financial grid, with haphazard regulations, a lack of banking competition, fines and 'cash and criminal' money markets causing further damage to their already fragile economies.

When banks are unwilling to enter a market, financial technology can supposedly step into the breach with innovations such as blockchain, which can be used to invent new ways of providing financial services to millions of excluded businesses and consumers. Therefore, African financial institutions need to open up their business strategies to embrace this new and disruptive technology. However, while there many questions and few answers, this disruptive technology is here to stay and the legal and regulatory mechanisms will have to play catch up in many ways. In order to accommodate this, domestic and regional legislations would have to undergo a change to cope with blockchain becoming a reality.[29]

[29] Prasad, Prakash. The Legal Aspects of Blockchain Technology (BCT).

REFERENCES

Antony Lewis, “Bits on Blocks”, Available at https://bitsonblocks.net/

Asian School of Cyber Laws, The Legal Aspects of Blockchain Technology (BCT), Prakash Prasad

Bitcoinwiki; 2015. Accessed: 24/3/2016. https://en.bitcoin.it.

BitHub.Africa, 2017,The African Blockchain Opportunity Report

Deloitte, 2017, Blockchain Enigma. Paradox. Opportunity, January 2017. Available at : https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/Innovation/deloitte-uk-blockchain-full-report.pdf

Euro Banking Association. (2015). Cryptotechnologies, a major IT innovation and catalyst for change: 4 categories, 4 applications and 4 scenarios. Available at : https://www.abe-eba.eu/downloads/knowledge-and-research/EBA_20150511_EBA_Cryptotechnologies_a_major_IT_innovation_v1. 0.pdf

European Central Bank (2012). Virtual currency schemes. ECB Report 2012. Available at : https://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemes201210en.pdf

Goldman Sachs , Blockchain : The new way of trust : available at : http://www.goldmansachs.com/our-thinking/pages/blockchain/

Harvard Business Review, 2017 “The Truth About Blockchain, https://hbr.org/2017/01/the-truth-about-blockchain “

Idebdou, N., 2015. A Game of Coins: The Digitization of Money and the Regulation of Virtual Currencies. Available at : https://ruor.uottawa.ca/bitstream/10393/32838/1/IDEBDOU%2C%20Nassiba%2020155.pdf

International Journal of Law and Information Technology , 2017 : Smart Contracts: Terminology, Technical Limitations and Real World Complexity by Dr Eliza Mik ,

International Journal of Management Sciences and Business Research , 2017, Blockchain Technology the New Internet by Dr. Zaffar Ahmed Shaikh, Dr. Intzar Ali Lashari , Apri 2017. Available at : http://www.ijmsbr.com/Volume%206%20Issue%204%20Paper%2019.pdf

KPMG,2016, Consensus Immutable agreement for the Internet of value , 2016 Available at : https://assets.kpmg.com/content/dam/kpmg/pdf/2016/07/kpmg-blockchain.pdf

Malta , Ministry for Education and Employment, Malta , 2017 . The working group on the future of post-seco
ndary education report to the Minister, January 2017

Massachusetts Institute of Technology , 2016, Digital Banking Manifesto: The End of Banks? By Alex Lipton, David Shrier, Alex Pentland. Available at : https://www.finextra.com/finextra-downloads/featuredocs/mit_digital_manifesto.pdf

McKinsey, 2016: A digital crack in banking's business model, By Miklos Dietz, Philipp Härle, and Somesh Khanna, April 2016. Available at : https://www.mckinsey.com/industries/financial-services/our-insights/a-digital-crack-in-bankings-business-model

McKinsey, 2015: Disrupting beliefs: A new approach to business- model innovation, by Marc de Jong and Menno van Dijk, July 2015.: Available at: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/disrupting-beliefs-a-new-approach-to-business-model-innovation

Morgen Peck, 2017, How Smart Contracts Work, Available at : https://spectrum.ieee.org/computing/networks/how-smart-contracts-work

Pillsbury Winthrop Shaw Pittman LLP : Blockchain Basics: A Primer", , https://www.pillsburylaw.com/images/content/1/0/v2/104160/AdvisoryMay2016CSTechBlockchainBasicsAPrimer.pdf

PC Magazine, Feb 6, 2017, Blockchain: The Invisible Technology That's Changing the World", , http://www.pcmag.com/article/351486/blockchain-the-invisible-technology-thats-changing-the-wor

PwC Technology Forecast , "Blockchain and Smart Contract Automation", , http://www.pwc.com/us/en/technology-forecast/blockchain.html

PwC global power & utilities , 2016,:Blockchain – an opportunity for energy producers and consumers?, Available at: https://www.pwc.com/gx/en/industries/assets/pwc-blockchain-opportunity-for-energy-producers-and-consumers.pdf

European Parliament, 2017, How blockchain technology could change our lives , Feb 2017 : Available at http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf

Rhodes University, 2016: The Possible Application of Blockchain Technology & Cryptocurrencies in the Financial Sector in Africa, Mazvita Wayne Chishakwe , 2016

Thomson Reuters, 2017, State of Regulatory Reform 2017, Special Report . Available at : https://www.finextra.com/finextra-downloads/featuredocs/2017-regulatory-reform.pdf

World Economic Forum , 2017 : Realizing the Potential of Blockchain A Multistakeholder Approach to the Stewardship of Blockchain and Cryptocurrencies, June 2017, Available at : http://www3.weforum.org/docs/WEF_Realizing_Potential_Blockchain.pdf

World Economic Forum, 2017, The future of financial infrastructure An ambitious look at how blockchain can reshape financial services, August 2016. Available at : http://www3.weforum.org/docs/WEF_The_future_of_financial_infrastructure.pdf